



Landfill Gas to Energy

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Landfill Inventory



- Approx 3000 Active Landfills Nationwide
- 329 WM Landfill Operations
 - 250 Municipal Solid Waste (WM owns gas rights)
 - 27 Contract Operations (WM does not have gas rights)
 - 52 Construction/Demolition Waste (limited gas)
- >150 WM Closed Landfills

Landfill Gas Generation

Anaerobic Decomposition of Organic Waste

- 45 to 55% methane, 45 to 55% carbon dioxide, with small amounts of oxygen, nitrogen, & non-methane organic compounds (NMOCs) and trace compounds. Typically 500 btu/scf.
- Gas Generation varies with:
 - Waste type
 - Waste age
 - Access to moisture
- Potential project sites: 400 to 4000+ mmbtu/day

Landfill Gas Regulations

Various regulations require the landfill operator to manage landfill gas (LFG) for the control of:

- Off-Site Underground Migration (RCRA Subtitle D)
- Groundwater Contamination (RCRA Subtitle D)
- Odors (local and state regulations)
- Fugitive NMOC Emissions through cap (NSPS)

Landfill Gas Collection System

System installed during active life of landfill and completed at closure of landfill.

- Vertical Wells drilled to bottom of waste
- Typically one well per acre
- Horizontal collectors in active fill areas
- Header pipe connecting wells
- Blower/compressor places vacuum on wells
- LFG delivered to flare or beneficial use project



WASTE MANAGEMENT, INC.



Collection System Well Head



WASTE MANAGEMENT, INC.



Collection System Header Pipe

Types of LFG to Energy projects

- On-Site Power Plants: minimal processing
- Medium Btu: minimal processing of gas
 - industrial boilers
 - utility power plants
 - asphalt plants, cement kilns, etc.
 - commercial heating
 - nurseries
- High Btu: processing to NG pipeline quality

Active LFG to Energy Projects

- 324 Active Nationwide (as of 6/01)
 - about 200 Power Plants (800 Megawatts)
 - about 100 Medium Btu
- WM Projects
 - 39 Power Plants (179.4 Megawatts)
 - 15 Medium Btu (LFG sold to GE, GM, Ford, etc.)
 - 2 High Btu (converted to pipeline grade NG)
 - Over 40 in negotiation, planning, or construction

Objectives of LFG to Energy Projects



- Incentive to maximize production of gas collection system
- Additional revenue from an otherwise liability
- Lower facility air emissions
- Public relations
- Tax credits

Medium Btu Project Economics

- Pipelines up to 10 miles may be feasible, depending on gas quantity.
- Potential revenue limited to natural gas market. LFG unit price usually set as a percent of NG.
- Net income varies with capital investment and O&M. Typical \$0.20 to \$0.50/mmbtu, but may achieve over \$1.00/mmbtu in best cases.
- Frequently capitalized by third party developer, who buys LFG from landfill and resells to end user.

On-Site Power Plant Economics

- Can be applicable to remote landfills (end user is on site).
- Potential revenue limited by energy market and other incentives, such as green power.
- Cost comparison to medium Btu:
$$1.0 \text{ cent/kwh} = \$0.85 \text{ to } \$1.00/\text{mmbtu}$$
- Cost to generate power ranges from 3.2 to 4.0 cents/kwh (\$2.70 to \$4.00/mmbtu).

On-Site Power Plant Economics

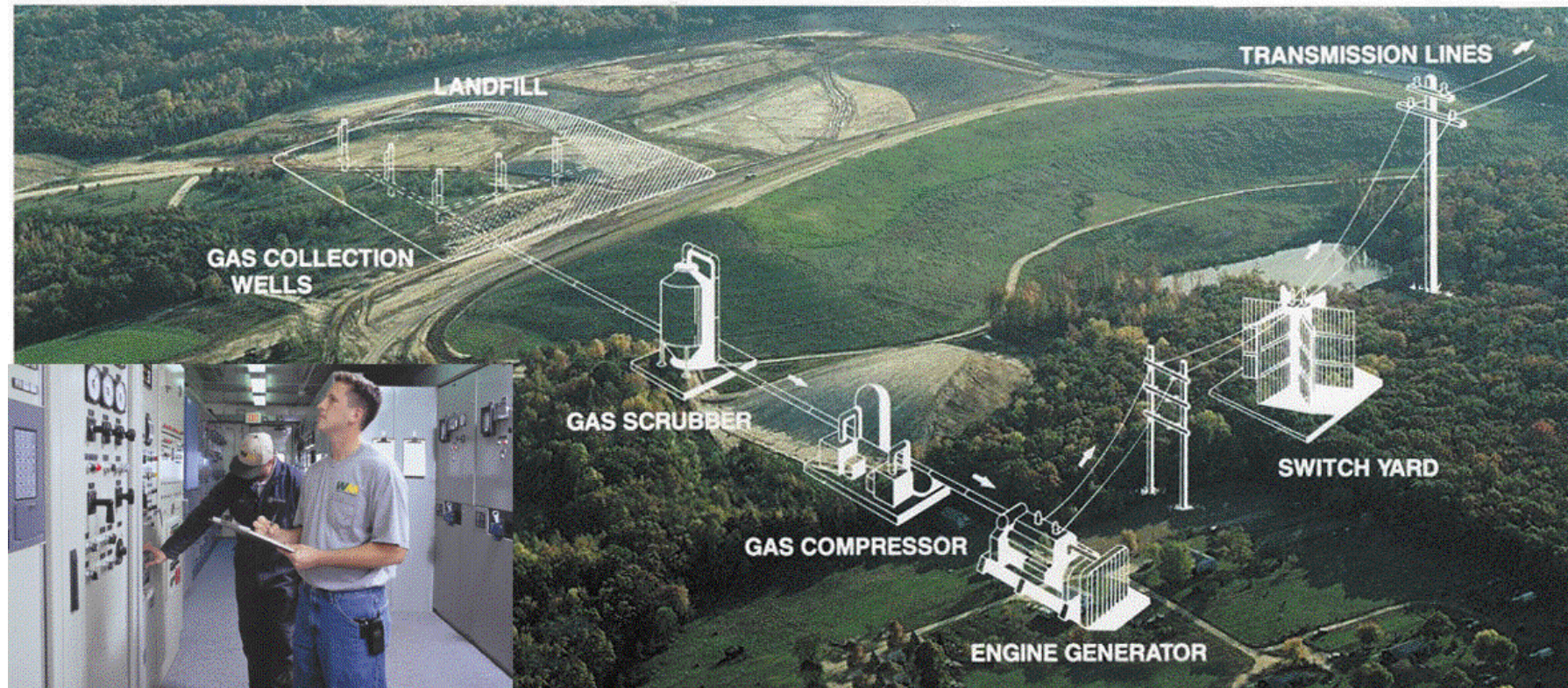
- Early projects sold power for 6 cents/kwh or more, achieving net income of over \$2.00/mmbtu.
- Current market is often less than 3 cents/kwh.
- With green power incentives, utilities and co-ops may pay over 3.5 cents/kwh, achieving net incomes of over \$0.30/mmbtu for highly efficient plants.
- Historically, third party capitalized project, purchased landfill gas, and sold power to utility.
- Recent interest from utilities, municipalities, and co-ops to capitalize plants.

3.2 MW Engine Plant



Landfill Gas to Energy Schematic

A TYPICAL LANDFILL GAS-TO-ELECTRICITY POWER SYSTEM



Evolving LFG Technologies

- Fuel for Fuel Cells (create electricity, heat, water and carbon dioxide)
- Fuel for Microturbines (create electricity & heat)
- Convert to LNG (vehicle fuel)
- Convert to CNG (vehicle fuel)
- Separate out (industrial grade) CO₂

New Technology Opportunities

(Economical) CLEANUP, CLEANUP, CLEANUP

- Removal of CO₂ - (could pay for itself)
- Removal of N₂ - needed for pipeline grade gas
- Removal of “long-chain” hydrocarbons - needed for conversion to LNG
- Removal of sulfur compounds - for operational reasons and to meet end users’ emissions limits
- Siloxanes - to reduce buildup in engines and prevent fouling of SCR catalysts

Bonus Benefit! ***Greenhouse Gas Emissions Reduced!***



- In the Kyoto treaty on greenhouse gas emissions, methane is considered 21 times as potent as carbon dioxide.
- A common interpretation is that the collection and destruction of landfill methane qualifies for greenhouse gas emissions credits if the landfill is not subject to NSPS emissions control.
- The value of these credits and the structure for trading the credits is not well-defined at this time.